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ABSTRACT

The United States needs a vocational educational system that delivers, in an applied technological setting, the new basic skills that industry needs, as well as a general education system that provides creative instruction in applied math, physics, and science. To be effective, technological training should encompass, along with machine-specific training, four components: (1) the basic reading, math, and study skills needed to cope with training for new technologies; (2) problem-solving skills that will enable workers to work out procedures, form theories, and draw abstract conclusions; (3) teamwork skills needed to identify the goals, values, and culture of the group, communicate with all members of a group, show sensitivity to others, and use a team approach to solving problems; and (4) technological literacy training in electronics, computers, robotics, applications, socioeconomic issues, and supporting subjects, such as physics and mathematics. Technological literacy provides an important bridge between basic skills training and machine-specific training, and enables workers to function in complex, ever-changing environments. Only through cooperation among industry, government, and individuals can a technologically literate workforce be developed. Information on how this model is applied at the Advanced Center for Technology Training in Michigan is provided throughout the text. (ALB)

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# TECHNOLOGY LITERACY: A KEY TO THE NEW BASIC SKILLS

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# TECHNOLOGY LITERACY: A KEY TO THE NEW BASIC SKILLS

My objectives today are to:

- Define the new basic skills — key among them technology literacy
- Increase your understanding of what is entailed in technology literacy training that distinguishes it from other sorts of literacy training
- Define the role of that training in producing an economically competitive workforce
- Provide an example of an approach that works to address the new basic skills training with an emphasis on technology literacy training

To understand how a technologically illiterate workforce impacts the economy of the United States, consider the comments made by Dr. Lester Thurow at a recent conference of City Managers. "At the end of World War II we were 75% of the World GNP. As late as 1960 we were 50% of the World GNP. Today we are just 23% of the world GNP. If you think about what is the competitive edge that any country has, it's something that's under your jurisdiction. The thing about which we compete [in the world] is, What's the quality of the local workforce in terms of education and skills? . . . if you look at the education and skills of our workforce, we just don't match up very well."[1]

In the nineteenth century, during the Industrial Revolution, the United States experienced rapid growth and became the leading industrialized nation in the world. The availability of an educated workforce proved to be an important aspect of that success. Consider the following analysis of American industry during the 1850s:

> "A fourth reason offered by British observers to explain American economic efficiency was an educational system that had produced widespread literacy and 'adaptive versatility' among American workers. By contrast a British workman trained by long apprenticeship 'in the trade' rather than in schools lacked 'the ductility of mind and the readiness of apprehension for a new thing' and was 'unwilling to change the methods which he has been used to,' according to an English manufacturer."[2]

Compare this observation with a recent statement made by Former U.S. Secretary of Labor William Brock: America needs an educational system with "much more emphasis on flexible training that allows people to adapt to technologies as they constantly change around them in the work place."

This remark has been hailed as innovative and visionary but we can see it is simply returning to the educational precepts and values that were originally responsible for

America's industrial development. What is required of America's educational system today?

I frequently hear discussion as to the purpose of education. Should education respond to business pressures and prepare students for specific jobs or should education prepare students for the future in which they will live? Alan Bloom in *The Closing of the American Mind* observes how "A highly trained computer specialist need not have had any more learning about morals, politics or religion than the most ignorant of persons." Those believing education should provide a more liberal arts background should take note of the recent statements made by industry leaders. It appears the ultimate goal of educators and industry's perceived need in its entry-level workforce are merging. David Kearns, Chairman and CEO, Xerox Corporation stated, "Indeed, the last thing Xerox and other high-tech companies need is vocational education. We need employees who are broadly and deeply educated, men and women who are 'liberally' educated."[3]

I am concerned that Kearns' statement regarding vocational education is an example of a polarization which is occurring in the education field. Compare Kearns' comment with one made by Charles H. Buzzell, Executive Director of the American Vocational Association, "Reading the popular press, it is easy to come away with the feeling that traditional vocational education programs are no longer appropriate at any level. . . . What absolute nonsense! Contrary to what some would say, employers large and small expect us to prepare students to arrive on the job ready to be productive."[4] I believe both gentlemen are correct. We need a vocational education system which delivers the new basic skills industry needs, but in an applied technological setting, and we need the general education system to adopt creative instruction in applied math, physics, and science.

## The New Definition of Literacy

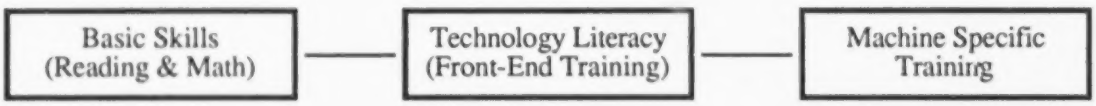
We must put into perspective the "widespread literacy" which the British observers identified in the United States during the 1850s. At that time, the commonly understood definition of **basic literacy** was being able to read and sign your own name. That notion was followed by a definition of **simple literacy** which included being able to read and comprehend short sentences. Brock's suggestion that we graduate workers who can adapt to technologies as they change around them in the workplace requires a much higher level of literacy than was found in the "adaptive versatility" of the American workers in the 1850s. This level of literacy is referred to as **functional literacy**.

Functional literacy includes the basic academic skills as well as knowledge in the areas of personal and interpersonal skills, communication, comprehension, quantification, critical thinking, and technology literacy skills. In addition one

must be able to apply those strategies that permit individuals to adapt information and skills for use in unfamiliar as well as familiar situations and contexts.

In the past, this combination of skills was seen as representing two distinct levels of skills — basic and higher-order. Today both skills are necessary. Together they will be referred to as the new basic skills, skills required for jobs we traditionally considered lower-level.

Our experience with today's American workforce suggests that effective technological training must have three components: *basic skills* training (reading comprehension and math skills), *machine-specific* training, and training to bridge the gap between them. This intermediary training is *technology literacy* (front-end training).




Analysts have identified the lack of both basic and technology literacy training as a major problem in successfully implementing automated manufacturing. Roger Smith, chairman and chief executive officer of the General Motors Corporation, admitted that GM has to implement more "upfront education and training of our workforce before high technology is introduced."[5] A two-year federal study commissioned by the National Academy of Engineering and released on June 17, 1987, also identified the lack of technology training programs.

The comprehensive objective of technology literacy training is to produce workers who do not have to be "retooled" as technology changes. Such an outcome provides greater use of existing human resources, and also brings the most effective return on expenditures for training resources.

To achieve this objective, we need a new way of thinking about learning. Because technology will continually change the worker's job, the worker will have to master new information and skills continually as well. Our concept of training must also move beyond that of training workers in single, static skills to one of preparing workers to function in complex, ever-changing environments.

The skills we are talking about here are generic and transferable; in a word, they are *employability skills*. We can identify four distinct kinds:

Traditional basic skills
Problem-solving skills
Teamwork skills
Technology Literacy

**Traditional Basic Skills**

Historically, providers of machine-specific training failed to identify the critical enabling skills needed to understand their training. For this reason, as training for automated equipment was introduced in this country during the last decade, the basic skills problem surfaced. Many adults in the workforce today do not have the necessary math, reading, and study skills needed to cope with the training for this new technology.

ACTT training begins with a criterion-referenced diagnostic assessment procedure that determines whether entering trainees have the necessary math, reading, and study skills to understand and work with the curriculum. In addition, a second assessment procedure assists ACTT in evaluating each trainee's technology literacy and readiness to undergo machine-specific training.

ACTT has incorporated a diagnostic assessment procedure to assist in identifying trainees' areas of need and guide them toward *targeted remediation.* This step is most important for guaranteeing successful mastery of the technology literacy curriculum. This allowed us to design the diagnostic procedure that provides trainees with inventory assessments of their math and reading comprehension skills as they relate to the technology literacy curriculum. A few of the specific math skills we assess include: Adding and subtracting three-digit numbers, identifying polygons, and understanding the X,Y coordinates.

We believe specific math and reading skills should be remediated as needed, at the time when the subject matter is introduced in the technology curriculum. This approach differs from separate or up-front skills training. Although there is on-going discussion in the educational community about this integrated approach to remediation, ACTT has had very positive outcomes in its JTPA-funded high school dropout programs. The ACTT approach neutralizes potential sensitivity a learner may have toward remediation, and doesn't withhold the motivating opportunity to work directly with the technology workstation.

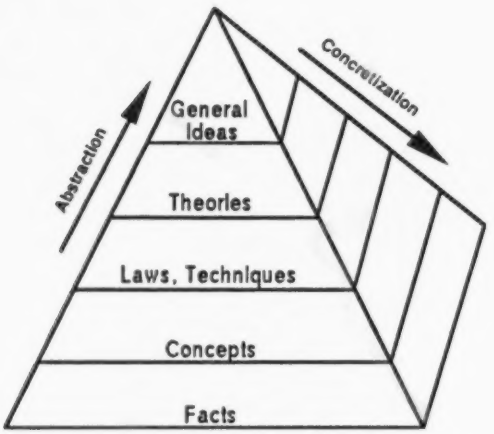
Trainees who lack specific reading or math skills that will be required to master the training modules are referred to appropriate instructional materials for targeted remediation. Trainees will also be trained in Individualized Self-paced Instruction techniques to ensure their acquisition of the basic skills necessary for success in the technology literacy program.

**Problem-solving Skills**

The ability to process information using abstract problem-solving skills (what Piaget defined as the fourth level of thinking[6]) is critical for workers in a high-tech workplace. In a study performed at the Center for Reemployment Services (CRS) in Charleston, South Carolina, researchers concluded, "Concrete thinking patterns . . . can make a person unemployable and eventually unable to survive in a high-tech world that increasingly calls for abstract thinking skills.

"Educators have assumed that people advance from concrete to abstract thinking by their early teens, but several psychological researchers have recently concluded that between 50 percent and 70 percent of adults have not achieved fourth-level thought."[7] ACTT's technology literacy training is based on a classical educational model of how human beings reason called the "thinking pyramid." This model produced a design for technology training that goes beyond skills and procedures to prepare workers to respond to changes in their working world.

The thinking pyramid epitomizes problem solving. We move up, down, or around the levels of thinking shown on the faces of the pyramid, with the back faces representing different, but related, topics. In problem solving we move upward from concrete data to work out procedures, form theories, and draw abstract conclusions. We move back down to more concrete thinking when we consolidate information, apply it to a problem, and test our solution. When we teach people these analytic skills along with, and applied to, technical information, they learn to solve existing, as well as new, problems by using their own internal problem-solving resources.




Educators are frequently criticized today for teaching just facts. Ironically, a primary objective of our front-end training is to graduate workers who can learn from facts and apply those facts to new processes or machines. By graduating workers who are comfortable with moving up and down this learning pyramid, you are graduating workers who can digest facts and require significantly less on-the-job training each time new machines or processes are introduced. Motorola Director of Training William Wiggenhorn explained why it cost more to teach Statistical Process Control to American workers than it cost to teach the same process to Japanese workers. "The Japanese simply hand their employees a book. American workers must first learn to read."[8]

ACTT has experienced significant success in developing these abstract problem-solving skills through a modular, hands-on, systems approach to teaching technology literacy. Trainees begin to develop problem-solving skills two-dimensionally using the LOGO programming language on the computer. This language provides immediate concrete results (movement on the screen) from abstract instructions. Too often in our educational experience we have been led to believe that there is a right answer and a wrong answer to a problem. Lauren Resnick, in her definition of higher order thinking skills included — "Yielding multiple solutions."[9] Seymour Papert discovered in the early seventies that LOGO overcame this "got it" or "got it wrong" barrier by teaching students to ask the question: is it fixable?[10] LOGO also permits the mastery of several skills simultaneously through parallel or incidental learning. These skills include: basic math, geometry, problem-solving, as well as computer programming concepts.

The advanced portions of the curriculum build on this Logo programming foundation by incorporating hands-on assignments with elements of technology (robots, sensors, stepper motors, servo motors, pneumatics, and logic control) to

further develop the basic and higher order thinking skills. In each assignment within the curriculum, some part of the hands-on workstation is used to master the objectives of the module. In essence we utilize an exciting "carrot" which holds the trainees' interest and tie the conceptual to the concrete. LOGO is the "carrot" in the early phases of the material, while the robot or sensors become the "carrot" in the more advanced phases of the material.

**Teamwork Skills**

Michigan Governor James J. Blanchard convened an Employability Skills Task Force in November, 1987, and charged it with identifying the generic skills and behaviors employers believed to be important across a broad range of business, service, and industrial sector jobs. The task force identified the following skills profile for teamwork skills :

**TEAMWORK SKILLS**
(Those skills needed to work with others on a job)
MICHIGAN EMPLOYERS WANT A PERSON WHO CAN:

- Identify with the goals, norms, values, customs, and culture of the group.
- Communicate with all members of a group.
- Show sensitivity to the thoughts and opinions of others in a group.
- Use a team approach to identify problems and devise solutions to get a job done.
- Show sensitivity to the needs of women, and ethnic and racial minorities.
- Be loyal to a group.

These required teamwork skills impose significant changes on the methodology of training in the classroom. For example, we encourage two people to a workstation in the beginning modules of our curriculum. During the more advanced projects we encourage three people to a workstation. Time is spent during our train-the-trainer program to instruct trainers on building groups, rotating the participants of each group during the course of the program, and dealing with problems that surface between members of the group. After all, is it reasonable to continue to insist that trainees work one-on-one at computer terminals or interactive video systems when the real world wants workers with strong communication and teamwork skills?

An example of the results from learning in groups surfaced during a JTPA-funded summer youth program at Washtenaw Community College, located in Ann Arbor, Michigan. The program consisted of ten economically disadvantaged youth between the ages of fifteen and eighteen exposed to our curriculum and methodology. Four of the participants were runaways from Detroit staying in halfway houses in Washtenaw County. When asked what's the most important thing

you've learned from the program, apart from the technical content?, one student responded, "Teamwork . . . Sometimes we disagree on how to solve a problem, so we try it both ways. We've learned that getting the right end result is more important than someone's pride getting in the way of cooperation."[11]

**Technology Literacy**

As I stated at the beginning of this presentation, one of my objectives today is to heighten your understanding of technology literacy training. I would now like to focus on the middle box of our three-box model, technology literacy training.

Michael Dyrenfurth of the University of Missouri jokingly defines a technologically illiterate person as one whose video tape recorder is still blinking 12:00 PM. But what does it mean to be technologically literate? First of all, let me clarify an important point. Being computer literate alone is not sufficient reason to be considered technologically literate. Too often in this country we teach our students a few lines of basic programming, a spreadsheet, and/or a word processor, and sit back and marvel at how technologically literate our students have become, or we use the computer as a tool in the learning process, or computer aided instruction (CAI) as it is called. While this may aid in the learning process it is not necessarily adding to the technology literacy level of the student. Let's not confuse instructional technology with technology instruction. Computer literacy is a part — but a small part — of technology literacy.

As defined by the Engineering Concepts Curriculum Project at the Polytechnic Institute of Brooklyn, a technologically literate person:

- Can use the decision-making process effectively.
- Can make valid predictions from models.
- Can use models to simulate real situations.
- Can use optimization techniques in making real world decisions as well as in classroom situations.
- Can demonstrate how feedback is used to control social, political, economic, ecological, biological, mechanical, and technological systems.
- Can predict from models when a system might become unstable.
- Can communicate with machines so that he or she uses the machine effectively.
- Is familiar enough with logic and logic circuits to understand that complex computers are made from simple circuits.
- Is willing to use the tools of technology to attempt solutions to real problems.
- Probes for causal relationships between science, technology and society.
- Questions the possible effects of technological "improvements" on the environment.
- Weighs the relative merits and risks of new products and processes.

- Recognizes the development of criteria and stating of constraints as subjective activities.
- Recognizes that technology will create entirely new possibilities for society. As a result the world will be a different place to live in the future, and that only knowledge of both technology and humanity can insure that it will be a better place to live in.[12]

The preceding characteristics provide an excellent listing of many of the skills required of a technologically literate person. Understanding the explanation of the four generic employability skills, I would like to suggest a guideline for technology instruction.

- Supporting Subjects — physics, mathematics (equations, geometry, algebra, and binary numbers), and systems.

- Electronics — basic logic elements, electronic components, circuits, analog and digital sensing devices.

- Computers — Operating system, programming, memory-mapped input/output.

- Robotics — robot programming, drive systems (servo motors, stepper motors, pneumatics, and hydraulics), coordinate systems, end-effectors, machine vision, computer control.

- Applications — integration of automation, applications criteria, artificial intelligence.

- Social and Economic Issues — historical survey, impact of technology (on work environment, individuals, and society), microeconomics, and macroeconomics.

**Guide on the Side Rather Than a Sage on the Stage**

One of ACTT's functions is to train trainers, rather than to provide training directly. The methods an instructor uses can facilitate the technology literacy learning process dramatically. We like to say that the trainer we graduate acts like "a guide on the side rather than a sage on the stage."

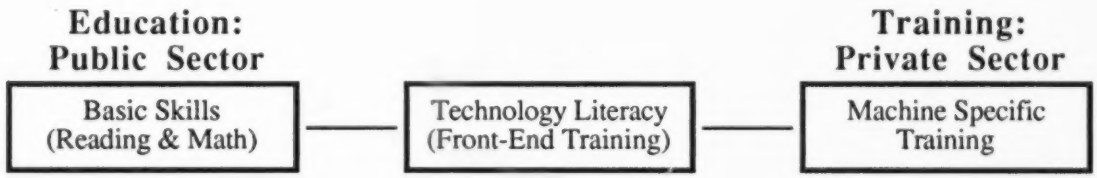
Instructors must be comfortable in situations where trainees have more control over the learning process. Instructors cannot be threatened with classrooms where the trainees may have more first-hand knowledge of the content than the instructor.

Remember, Einstein was removed from school because he continued to ask questions that his teachers could not answer. We can be thankful that Einstein's mother encouraged him to continue asking those questions. The same is true for the technology literacy instructor. It is imperative that instructors encourage students to go beyond the restraints of formal curricula. Instructors who can encourage trainees to release their intuitiveness will find the learning process proceeds further and faster than imagined.

**Public or Private Funding**

The final issue to discuss is the funding source for technology literacy programs. Is this kind of training an extension of one's basic skills and therefore the responsibility of the traditional education system? Or is this training job related and therefore the responsibility of the employer to provide?

The three-box model described earlier shows easy solutions for the left and right boxes. Most people are in agreement that the box on the left is called "education" and the public sector of the economy is responsible for its funding. The box on the right is called "training" and the private sector (employer) is responsible for its funding. The box in the middle is not as easy to describe. To some it is personal enhancement and to others it is job-related.




The skills included in the characteristics of a technologically literate person are skills which should be mastered upon graduation from high school. However, as long as we are dealing with a current workforce which is deficient in these skills, some form of joint partnership must be developed by industry, government, and the individual, to provide this training.

We can see the importance of a technologically literate workforce on the American competitiveness. It is up to all of us to explore new ways with which to achieve our goal of a technology literate America. Only through cooperation among the various segments of the public and private sectors can we truly succeed in the monumental endeavor.

1 Excerpt from The Zero-Sum Solution, delivered at the 73rd Annual Conference, International City Management Association, Montreal, Canada, October 25-28, 1987, Lester C. Thurow, Professor and Dean, Sloan School of Business Administration, Massachusetts Institute of Technology.

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